Asset Price Spillover: Fundamental vs. Bubbles in Korean Housing Market[1]

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This paper investigates price diffusion within the housing market of Korea, focusing on two geographically adjacent regions of Seoul, i.e., Gangbuk (to the north of the river) and Gangnam (to the south of the river). Contributing to the literature on the ripple effect in housing markets, the study examines the interdependence of the submarkets with respect to the fundamental and bubble components of house price separately. For that aim, the presence of speculative bubbles in either submarket is checked, and the actual prices are decomposed into the fundamental and bubble components following a present-value approach. We then examine the presence and directions of house price spillovers across the two submarkets using the Granger-type causality test. A few key features emerge. First, long-run relationships are evident between the two submarkets for both the fundamental and bubble component alike, according to the unit root test for price ratio and the cointegration test. Second, the causality test also highlights that price diffusion does occur over the short-run from Gangnam to Gangbuk. Third, the above price diffusion between the two submarkets is not observed for the fundamental prices but the bubble components, supporting the presence of a unidirectional bubble contagion in the short-run from Gangnam to Gangbuk region.

Keywords: House Prices, Regional Housing Market, Fundamentals, Bubble,

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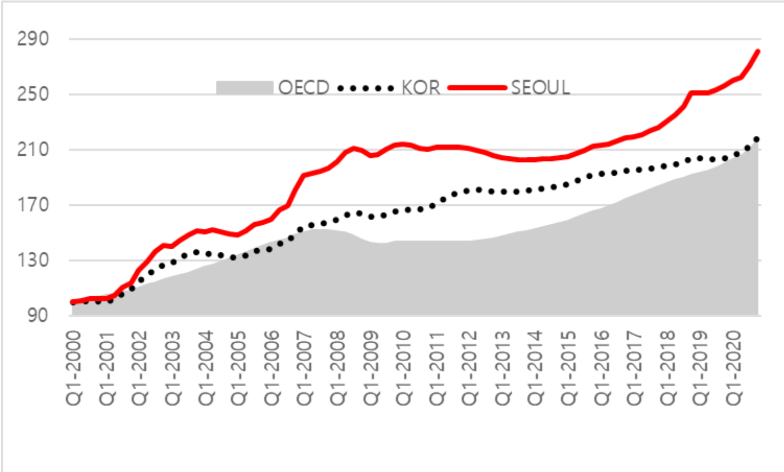
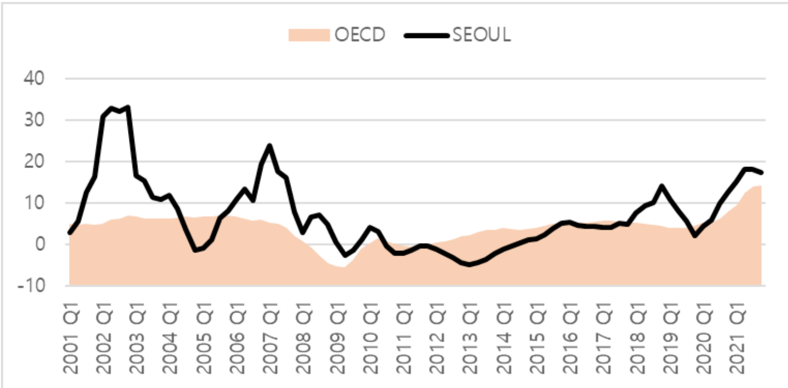
1. Introduction

In the past two decades, the real estate market in Korea witnessed a continued increase in housing prices, and such an elongated housing market euphoria has been most conspicuous in its capital city Seoul. Figure 1 shows how heated and volatile the housing market of Seoul has been in comparison with the whole OECD countries. Over the period of 2000:Q1 - 2020:Q4, the nominal house price in the whole countries (in shade) increased at the rate of 3.95 percent (CAGR). During the same period, the nationwide Korean housing market (in dotted line) registered a comparable rate of growth as high as 3.98 percent (CAGR) without experiencing discernible slowdown. In comparison, the housing market dynamics in Seoul (in solid line) is much more conspicuous and exuberant, both in terms of the annual growth rate (5.3%) and the volatility of the market demonstrated by the episodes of boom-bust cycles.

Constituting a large portion of most households' portfolios, house prices at the national level are central for the macroeconomic impact of the housing market and the discussion of fiscal and monetary policies. Notwithstanding, we believe that it is also crucial to take regional variations into account issue when examining housing market dynamics. As highlighted in Himmelberg et al. (2005), house price dynamics are a local phenomenon since housing markets are genuinely segmented: there is not a unique national housing market, but rather many regional markets exhibiting quite heterogeneous house price developments. In addition, movements in price in one region of the housing markets can spill over spatially across different regional markets and thereby affect the national market, a phenomenon known as the 'ripple effect' examined by the seminal work by Meen (1996, 1999). That being the case, regional heterogeneity in house price dynamics may have important implications, not



(a) Levels, with 2001:Q1=100



(b) Rates of changes, year-over-year

〈Figure 1〉 Nominal House Prices in OECD and Korea[4]

only due to potential spillovers to other regions but also as policymakers need to take this diversity into account when designing appropriate policy measures. By exploiting cross-section variability, the use of regional data also allows a better estimation of the parameters of interest, e.g., the long-run relationship between house prices and their structural determinants.

In this vein, the 'regional' approach has frequently been implemented in the

(4) House price series are obtained from *Analytic House Price Indicators* (OECD) and *Kookmin Bank Real Estate Dataset* (Korea and Seoul).

literature For instance, Holly et al. (2010) exploit US state-level panel data from 1975 to 2003 and take explicit account of both cross-sectional dependence between US states and parameter heterogeneity. Other studies, e.g., Clark and Coggin (2011), Gallin (2006), Capozza et al. (2002) and Malpezzi (1999), exploit US regional data to test for a cointegrating relationship between house prices and their long-run fundamentals. Similar analyses have been performed for other countries such as China, e.g., Mao and Shen (2019) and the UK, e.g., Tsai (2015). Specifically, the latter study finds that house prices in London do not influence the housing markets of other regions and during the 2008 global financial crisis the decline in housing prices in the Northern regions of the UK is as significant as those in the overall market. However, the house prices in the Northern regions did not rebound as the overall market did after 2009, reinforcing the existence of the North–South divide.

As an addition to the literature of the regional approach to housing market, the current paper has two aims. We first examine the city-level housing market in Seoul, focusing on the possibility that the movements of property prices reflect speculative bubbles rather than housing market fundamentals. We then analyze the dynamics of housing markets in Seoul in the context of interconnected submarkets in a metropolitan area, as in Meen (1996,1999) and Adair et al. (2000). As will be discussed in more detail in the following section, we view the city of Seoul as an ideal testbed for the study of regional house price dynamics composed of two districts yet highly connected submarkets, i.e., Gangbuk and Gangnam regions within Seoul geographically divided by Han river flowing through the capital city. Exhibiting a considerable degree of interrelation and differentiation at the same time, the two submarkets in Seoul can unveil important information that is usually overlooked by studies done at the national or city-wide level.

In terms of methodology, we adopt a two-stage strategy to examine the regional housing market of Seoul. At the first stage, we examine the presence and magnitude of speculative housing bubble in the two submarkets of Seoul between 2000 and 2020. To check for the presence of speculative bubble, we employ the GSADF test developed by Phillips et al. (2015) that can detect and date multiple episodes of explosive bubbles followed by collapses. Based on the results of the GSADF test, we then construct and estimate a present-value model incorporating periodically collapsing bubble and separately identify the fundamental and bubble components of housing prices in each submarket. We then proceed to the second stage of the study. The main task here is to examine the presence and degree of ripple effect between the two submarkets, but more emphasis is placed on whether the inter-regional spillover reflect that of the fundamental part of the house price or the contagion of bubbles. For this purpose, we examine the presence and directions of house price spillovers across the two submarkets using the Granger-type causality test.

Some key findings emerge from the current study. First, the GSADF test supports that housing bubbles existed in the two housing submarkets, especially in the two periods during the mid- to late 2000s and from 2017 on. The results of fundamental-bubble decomposition also reveal that there have been accumulations of bubble on either side of the river since the mid-2000s. Second, stable long run relationships are found between the southern and northern parts of Seoul, for the pair of the actual, fundamental, and bubble prices alike. This indicates that the two submarkets are not segmented but converge to a single market over time and that there is a ripple effect within a greater single housing market. Third, the causality test shows that there is a diffusion of house price between the two submarkets. More specifically, the diffusion identified by the test works in the direction from Gangnam to Gangbuk confirming the dominant role of the high-priced submarket in the diffusion of price increases. Furthermore, such diffusion of prices appears not between the fundamental components but between the bubble components, strongly support the case of short-run bubble contagion from Gangnam to Gangbuk.

This paper is organized as follows. Section 2 discusses the delineation of two submarkets in Seoul upon which the subsequent empirical exercises are based on. Section 3 then test*s* the presence of speculative bubbles and perform the fundamental-bubble decomposition of housing prices in each submarket. The results of investigation into the ripple effect or price diffusion across the submarkets are presented in Section 4. Finally, section 5 concludes the paper.

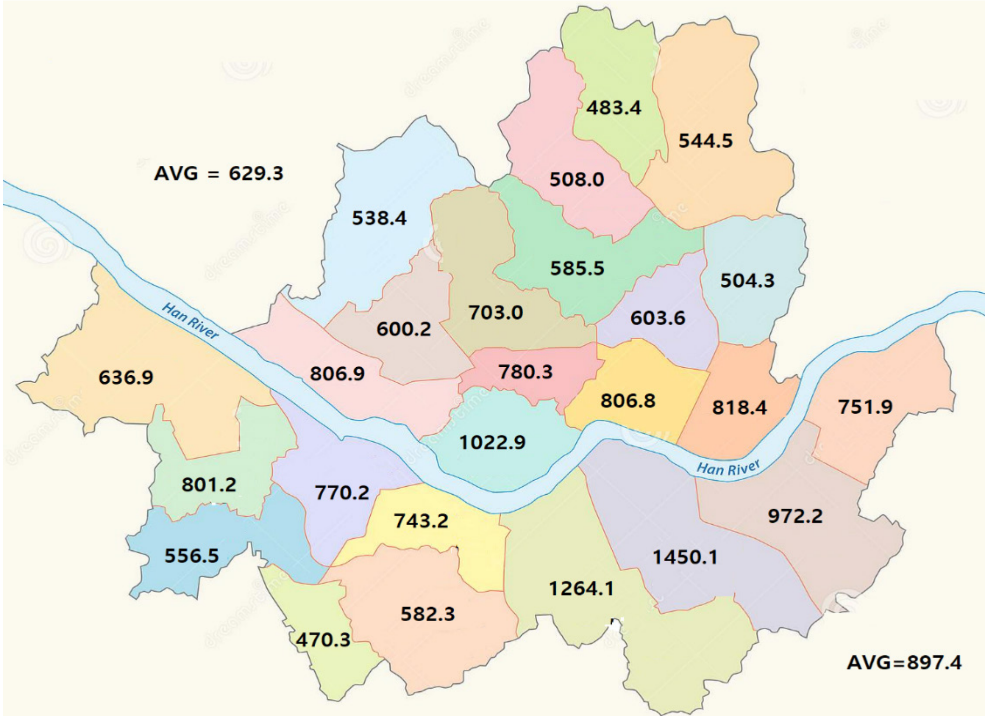
2. Housing Submarkets in Seoul

As posited in Bourassa et al. (1999), a housing submarket can be defined in general terms as “a set of dwellings that are reasonably close substitutes of one another, but relatively poor substitutes for dwellings in other submarkets”. Notwithstanding, devising a universally accepted set of criteria for delineating housing submarkets is not an easy task since many aspects of constituent housing markets, e.g., structural attributes of the properties, the degree of house price substitutability, socio-economic characteristics of neighborhoods, and spatial delimitations, etc., are involved in so doing. For the case of Seoul, however, there is an unofficial yet widely accepted delineation of two major submarkets. As shown in Figure 2, the area of Seoul is divided into two adjacent regions, i.e., Gangbuk and Gangnam areas located on the opposite banks of the Han river.(5) Ganguk, referring to ‘the north side of the river’, comprises 14 boroughs with the total population of 4.62 million as of 2023:Q1. The ‘south side of the river’, dubbed Gangnam, has 11 boroughs and 5.04 million residents. Since the early 80s when the southern part of Seoul began to be developed as a new town, Gangnam has been increasingly considered the high-class neighborhood close to the main business hub. In contrast, the opposite part of the city has long been characterized as a traditional lower-to-middle class neighborhood.

To the extent that the prices of housing units reflect many, if not all, of economic factors driving the housing markets they are located in, Figure 2 shows a reasonable degree of disparity and differentiation between the two submarkets of Seoul: the average of housing price per ‘pyeong’ over 2003:Mar to 2020:Dec is 629.3 (million Won) in the northern part of Seoul, whereas that in the southern part is as high as 897.4 million Won.(6) Furthermore, whereas five among the fourteen boroughs in Gangbuk area have housing prices higher than the city-wide average of 733.2, it is

(5) In Figure 2, Gangnam “borough” and Gangbuk “borough” are individual boroughs in Gangnam and Gangbuk area, respectively.

(6) Equivalent to 3.306 square meter, ’*pyeong’* is the traditional standard measure for square footage and floorspace in Korea.



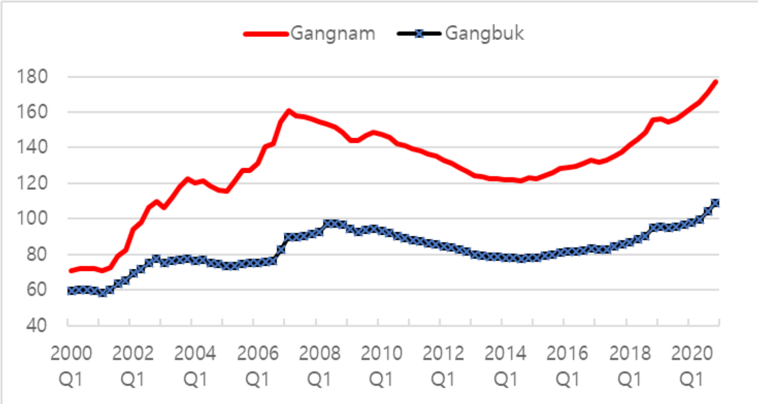
Source: Kookmin Bank Real Estate Dataset (authors' calculation)

〈Figure 2〉 Average Apartment Prices in Districts of Seoul

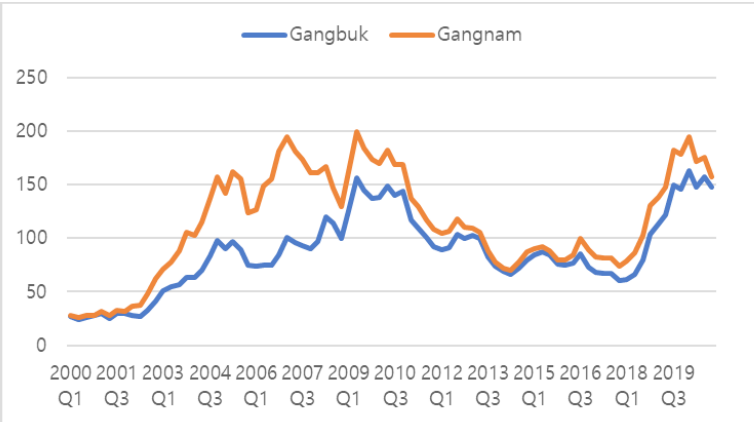
the case in seven among the eleven boroughs across the river. As such, we view the two regions of Seoul constitute a reasonable pair of housing submarkets for a study of regional and inter-regional housing price dynamics.

Figure 3 shows how differentiated the two submarkets are in terms of the real purchase price and rent series for apartments.[7] Panel (a) show that the overall movements of real apartment prices demonstrate that both submarkets share similar dates for real estate cycle, i.e., a bullish run in the early to mid-2000s, a dormancy of six to eight years in the wake of the global financial crisis, and the recent and ongoing housing boom that pushed housing price up to historically unprecedented

(7) Roughly equivalent to the condominiums in the US, apartments are a dominant type of dwellings in Korea. Easy to mass produce with highly standardized materials and floor plans, apartments are physically much more homogenous than are dwellings in other countries, which greatly facilitates the collection and processing of transactions and prices data.



(a) Real Apartment Prices



(b) Annualized Real Rents[(9)]

〈Figure 3〉 Prices and Rents Series in the Submarkets of Seoul

levels. The disparity in housing prices has been widening over time, however, which supports the view of treating the two submarkets as connected yet distinct. Specifically, house prices are consistently lower in the Gangbuk submarket relative to the other throughout the data period. Plotting the annualized real rent series, panel (b) further support the possible fundamental disparity between the two submarkets.[(8)] Such

(8) As pointed out by an anonymous referee, many districts (other than Gangnam, Seocho, and Songpa) in the Gangnam area have characteristics similar to those in the Gangbuk area. We opted for the two-submarket analysis and relegated them into the whole Gangnam area, since the house price data at the district level are only available from the year 2013 on.

differentials between the two submarkets are also consistent with the documented disparities between the two regions in terms of other socio-economic aspects, e.g., income and wealth, education, health, and employment opportunities.

3. Decomposition of House Prices: Fundamental vs Bubble

3.1 Detecting Explosive Behavior in the Housing Submarkets

As a pretest prior to engaging in the bubble-fundamental decomposition, we check for the presence of speculative bubbles in the two submarkets. For this aim, we resort to the generalized supremum ADF (GSADF) test developed by Phillips et al. (2015) capable of detecting possibly multiple episodes of explosive behaviors in asset prices. This method is based on the generalized form of ADF test regression

$$\Delta y_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} y_{t\text{-}1} + \Sigma_{i=1}^{K} \phi_{r_1,r_2}^{i} \Delta y_{t\text{-}i} + \varepsilon_t \qquad (3.1)$$

where y_t is the asset price, α is the intercept, K is the lag order, and (r_1,r_2) represents the intervals of subsamples for which equation (1) is estimated. The GSADF test consists of repeated estimation of equation (1) on subsamples of data in a recursive fashion, where the null hypothesis $\beta_{r_1,r_2} = 0$ (i.e., a unit root in y_t) is tested against the alternative hypothesis $\beta_{r_1,r_2} > 0$ (i.e., an explosive behavior in y_t). The test statistic is the largest ADF statistic over the possible ranges of r_1 and r_2:

$$GSADF(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \{\sup_{r_2 \in [r_0, 1]} \{ADF_{r_1}^{r_2}\}\} \qquad (3.2)$$

where a GSADF statistic larger than a critical value rejects the null hypothesis and then the series $\{y_t\}$ is diagnosed as exhibiting explosive behavior.

(9) The details of constructing the annualized rent series are discussed later in section 3.

Once the null hypothesis is rejected, the backward SADF (BSADF) statistic is obtained by running the rolling supremum test backward:

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in [0, r_2 - r_0]} \{ADF_{r_1}^{r_2}\} \tag{3.3}$$

where the origination date r_e of an explosive bubble is determined as the first chronological date at which the BSADF statistic exceeds the critical value from below:

$$r_e = \inf_{r_2 \in [r_0, 1]} \{r_2 : BSADF_{r_2}(r_0) > CV\}, \tag{3.4}$$

and the termination date r_f of a bubble is determined as the first date after r_e at which the BSADF statistic falls below the critical value from above:

$$r_f = \inf_{r_2 \in [r_e, 1]} \{r_2 : BSADF_{r_2}(r_0) < CV\}. \tag{3.5}$$

The results of GSADF and BASDF tests for the real apartment prices in the two submarkets are presented below. Table 1 shows the test statistics for the GSADF test along with the p-values in parentheses, where we also report the results of the standard left-tailed ADF test performed to help better interpret the results of

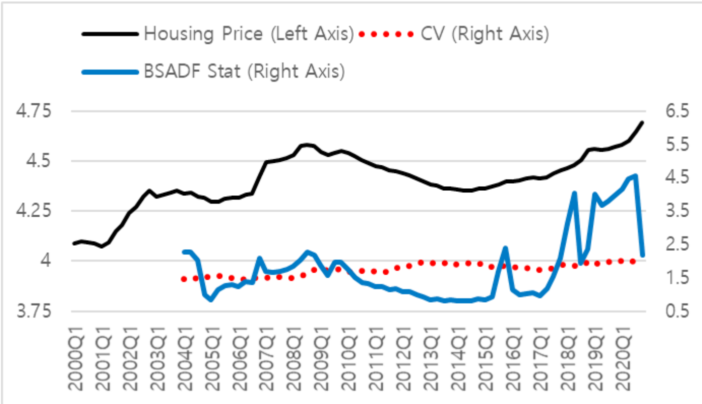
〈Table 1〉 Results of Bubble Tests for Real House Prices

	ADF H0 unit root vs. H1: stationary		GSADF H0 unit root vs. H1 explosive	
	No intercept	With intercept	No intercept	With intercept
GB	-2.593 (0.971)	-1.274 (0.638)	4.560 (0.006)**	4.782 (0.002)**
GN	1.808 (0.983)	-2.331 (0.165)	5.719 (0.001)**	5.162 (0.000)**

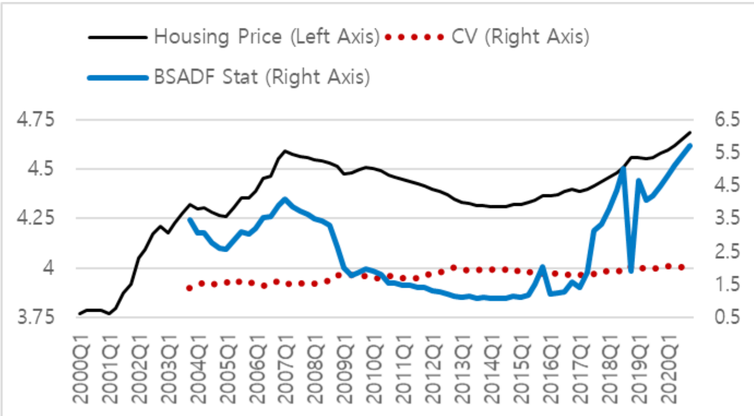
Note: Both tests are performed by Eviews 10, and the GSADF test statistics and relevant critical values are obtained from the RTADF EViews add-in contributed by Caspi (2013). Numbers in parentheses are the p-values. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively. The p-values for the GSADF tests are calculated by Monte Carlo simulations with 1000 repetitions.

the GSADF test. The standard ADF test fails to reject the null of unit root at any practical level of significance whether the test is run with or without the intercept. The second column presents the results of the GSADF test. For both submarkets, the GSADF statistics are significant at the 1% and large enough to reject the null of simple unit root in favor of the explosiveness of the housing price in both submarkets.

The chronology of explosive bubbles detected by the backward SADF (BSADF) statistics is plotted in Figure 4. The BSADF statistic and the 95% critical values are plotted in red dashed line and blue dotted line, respectively. If we disregard some isolated episodes of bubble shorter than two quarters, three major occurrences of



(a) Gangbuk



(b) Gangnam

〈Figure 4〉 Bubble periods in the two submarkets bubble are detected for the Gangbuk region:2000:Q1-2004:Q3, 2006:Q4-2010:Q1, 2017:Q4-2020:Q4. Meanwhile, the bubble episodes for the Gangnam region, identified during 2003:Q4-2010:Q2, 2017:Q2-2020:Q4, in terms of the duration and magnitude.

Overall, the results of GSADF test indicate that the two submarkets of Seoul have undergone multiple episodes of explosive bubbles since 2000, and that two main periods of bubble are detected: the first one is from the early 2000s to the initial stage of the global financial crisis, and the second one since 2017 on. Based on the results of bubble detection, we proceed to a separate identification of the bubble and fundamental parts of house prices.

3.2. The Present-Value Model

To decompose housing prices into the fundamental and bubble parts, we employ a modified present value model incorporating bubble in the spirit of Campbell et al. (2009) and Balke and Wohar (2009). The realized gross real return from holding a housing unit is

$$H_{t+1} = (P_{t+1} + R_{t+1}) \,/\, P_t, \tag{3.6}$$

where H_{t+1} denotes the real gross return on a home held from time t to t + 1, P_{t+1} is the real house price at the end of period t+1, and R_{t+1} is the real rent payment received from time t to t+1. Applying the Campbell–Shiller approximation to (1), we obtain

$$pr_t = \kappa + \rho pr_{t+1} + \Delta r_{t+1} - h_{t+1}, \tag{3.7}$$

where $pr_t = \log(P_t / R_t)$, $r_{t+1} = \log(R_{t+1}/R_t)$, $h_{t+1} = \log(H_{t+1})$, $\rho = e^{\overline{pr}} / (1 + e^{\overline{pr}})$, $\overline{pr}$ is the average of the log of the price–rent ratio over the sample, and K is a linearization constant. Without any explosive behavior in pr_t, we obtain the following standard present-value formula:

$$pr_t = \frac{\kappa}{1-\rho} + E_t\{\textstyle\sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1})\}, \tag{3.8}$$

i.e., the log of the price–rent ratio is a weighted discounted sum of the expected future rent growth Δr_{t+j+1} and gross real return h_{t+j+1} for $j \geq 0$.

Two modifications are made to the present-value formula (7). First, similarly to that in Campbell and Ammer (1993) and Campbell et al. (2009), the log of gross real return, h_t, is broken down into the real interest rate (i_t) and the excess rate of return (π_t).(10) Second, we allow the presence of bubble in the price–rent ratio:

$$pr_t = \frac{\kappa}{1-\rho} + E_t\{\textstyle\sum_{j=0}^{\infty} \rho^j (\Delta r_{t+j+1} - i_{t+j+1} - \pi_{t+j+1})\} + b_t = pr_t^f + b_t, \tag{3.9}$$

where pr_t^f is the fundamental price–rent ratio determined by the expectations of the three housing market fundamentals (Δr, i, π), and b_t represents rational speculative bubbles. In particular, we follow Balke and Wohar (2009) and specify b_t as a periodically collapsing bubble that switches between non-exploding and exploding regimes.

As in van Binsbergen and Koijen (2010), we treat the one-period-ahead expectations of rent growth, $g_t = E_t[\Delta r_{t+1}]$, real interest rate, $\mu_t = E_t[i_{t+1}]$, and housing risk premium, $\lambda_t = E_t[\pi_{t+1}]$, as unobserved components following autoregressive AR(2) processes:(11)

$$g_t - \gamma_0 = \gamma_1(g_{t-1} - \gamma_0) + \gamma_1(g_{t-1} - \gamma_0) + \varepsilon_t^g, \tag{3.10}$$

$$\mu_t - \delta_0 = \delta_1(\mu_{t-1} - \delta_0) + \delta_2(\mu_{t-2} - \delta_0) + \varepsilon_t^\mu, \tag{3.11}$$

$$\lambda_t - \theta_0 = \theta_1(\lambda_{t-1} - \theta_0) + \theta_2(\lambda_{t-2} - \theta_0) + \varepsilon_t^\lambda, \tag{3.12}$$

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(10) The former corresponds to the risk-free rate of return, and the latter reflects the risk premium or excess returns for investing in housing assets.

(11) During the early stage of this study, we also tried the AR(1) specification, but the AR(2) specification fit the data better.

where the innovations $\varepsilon_t = (\varepsilon_t^g, \varepsilon_t^\mu, \varepsilon_t^\lambda)$ can be interpreted as the effects of news on the expectations. We assume that ε_t follows an independent and identically distributed (i.i.d.) Gaussian process with a general covariance matrix Σ_ε.

The realizations of the bubble regime are governed by a hidden state variable, S_t, which follows a Markov regime-switching process with the transition probabilities,

$$\text{Prob}[S_t = 1 \mid S_{t\text{-}1} = 1] = P_1, \quad \text{Prob}[S_t = 0 \mid S_{t\text{-}1} = 0] = P_2, \tag{3.13}$$

which are time-invariant and independent of any other disturbances. In the regime with $S_t = 0$, b_t follows a stationary AR process:

$$b_t = \bar{b} = \psi b_{t-1} + \varepsilon_t^b,\ 0 < \psi < 1, \tag{3.14}$$

where b_t slowly dies out in the absence of the innovation ε_t^b in the bubble.(12) This regime is dubbed as a non-exploding regime. If the regime switches from non-exploding to exploding (i.e., $S_{t\text{-}1} = 0$ is followed by $S_t = 1$), then b_t evolves as

$$b_t = \frac{q}{(1-q)}\bar{b} + \frac{1}{1-q}\left[\frac{1}{\rho} - q\psi\right]b_{t-1} + \varepsilon_t^b. \tag{3.15}$$

Finally, if the exploding regime continues (i.e., $S_{t\text{-}1} = 1$ is followed by $S_t = 1$), then we obtain

$$b_t = -\frac{(1-p)}{p}\bar{b} + \frac{1}{p}\left[\frac{1}{\rho} - (1-p)\psi\right]b_{t-1} + \varepsilon_t^b. \tag{3.16}$$

Since the bubble is specified in the price-rent ratio, we do not impose the non-

(12) We specify ε_t^b as a Gaussian i.i.d. process that is independent of any other disturbances or innovations.

negativity constraint In the specifications (11a)-(11c). A few previous studies, e.g., Weil (1990), argue on theoretical grounds that an asset can be undervalued when the economy is in a bubble equilibrium.

The model is closed with the measurement equations that relate the observed data to their model counterparts. The actual price-rent ratio is related to the unobserved model components (g_t, μ_t, λ_t, b_t) via (9a)-(9c) and (11a)-(11c), and the observations of the rent growth and real interest rate are equal to the sum of their respective one-step-ahead expectations and idiosyncratic innovations:

$$\Delta r_t = \gamma_0 + g_{t-1} + u_t^r, \quad i_t = \delta_0 + \mu_{t-1} + u_t^i, \tag{3.17}$$

where the unexpected innovations, $u_t = (u_t^r, u_t^i)$, follow Gaussian i.i.d. distribution with a diagonal covariance matrix, $\Sigma_u = \text{diag}(\sigma_r^2, \sigma_i^2)$. We further assume that ε_t and u_t are mutually uncorrelated at any leads and lags. The present-value model thus constructed is cast into a state-space form with Markov switching, and can be estimated via the approximate maximum likelihood method of Kim and Nelson (1999).(13)

The present-value model constructed above is estimated with quarterly data spanning 2000:Q1 to 2020:Q4. The raw dataset used in the current study includes the nominal purchase and chonsei price indexes of each submarket, two nominal interest rate series, and two consumer price indexes, all spanning 1999 to 2020. The purchase and chonsei prices are obtained from Kookmin Bank database, which is constructed via inquiries about the prices of sample properties sent out to real estate brokers every month.(14) The two nominal interest rate series are the AA minus rated corporate bond yields with a 3-year maturity and the national housing bond yields, both obtained from ECOS (Economic Statistics System) of the Bank of Korea.(15) The CPI for all

(13) More details of the state-space model are summarized in the appendix.

(14) As such, the purchase and *chonsei* price indexes thus constructed may include the "asking" prices of sample properties that are not sold or rented in a particular period. Notwithstanding, those indexes are considered highly accurate since price information on similar units is readily available to the public even daily.

(15) Of the two interest rates, the former is usually used as the representative market rate in

items and the core CPI (i.e., CPI less agricultural and petroleum products) are also obtained from the Bank of Korea database. All monthly raw series are transformed into quarterly ones by taking within-quarter averages.

Since the purchase and chonsei prices are only available as indexes, we need to rescale either of them to accurately reflect their actual relative magnitudes.(16) To do so, we rescale the chonsei price index to match the average purchase-chonsei price ratio for the year of 2000 on average.(17) We also note that Chonsei contracts do not involve explicit monthly rent payments. Therefore, we calculate the implicit rent payments by multiplying the rescaled chonsei price series with the AA minus rated corporate bond yields (adjusted for the quarterly frequency). Finally, we construct the risk-free real rates of return from housing investment as the difference between the nominal National Housing Bonds rates and the year-on-year ex-post inflation in the core CPI.

3.3 Results of Fundamental-Bubble Decomposition

The estimated present-value model is presented in Table 2 where only some key results are reported to save space.(18) The left panel shows that the expectations of future real interest rate and excess returns change only very slowly as implied by the estimated long-run AR coefficients, i.e., $\delta_1 + \delta_2$ and $\theta_1 + \theta_2$ are around 0.93 or larger in both submarkets. In contrast, the expectation of future rent growth exhibits only a modest degree of persistence with the long-run AR coefficient around 0.2. The estimated properties of the bubbles are reported in the right panel, where the bubble components are also sharply estimated. The initial size of bubble $\bar{b}$ is significant in both submarkets and larger in the south of the river than in the north. The estimated AR coefficient and regime switching probabilities imply that the evolution of the

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Korea and the latter is considered risk-free rates related to housing market.

(16) Obtaining properly rescaled series of price and rents is crucial in putting the present-value model to data.

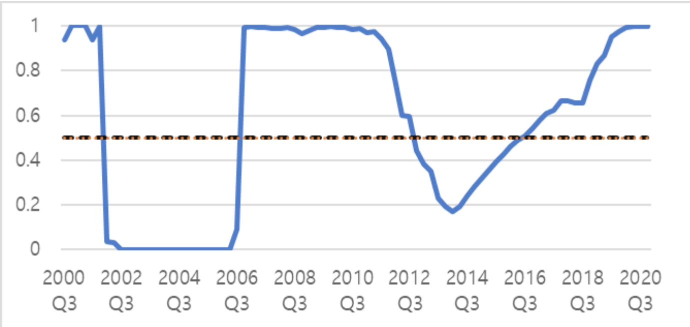
(17) The ratios of chonsei to purchase price for apartments are available from 1998:DEC.

(18) The full estimation results are available from the authors upon request.

〈Table 2〉 key estimates of the present-value model

	Fundamental Parameters						Bubble Parameters			
	γ_1	γ_2	δ_1	δ_2	θ_1	θ_2	p	q	ψ	$\bar{b}$
KB	0.231	-0.009	1.384	-0.41	0.753	0.180	0.992	0.934	0.899	0.084
	(0.061)	(0.011)	(0.070)	(0.066)	(0.152)	(0.142)	(0.001)	(0.003)	(0.001)	(0.03)
KN	0.209	-0.007	1.266	-0.303	0.686	0.242	0.991	0.930	0.897	0.106
	(0.061)	(0.010)	(0.044)	(0.042)	(0.048)	(0.045)	(0.005)	(0.001)	(0.001)	(0.001)

Note: standard errors are in parentheses.

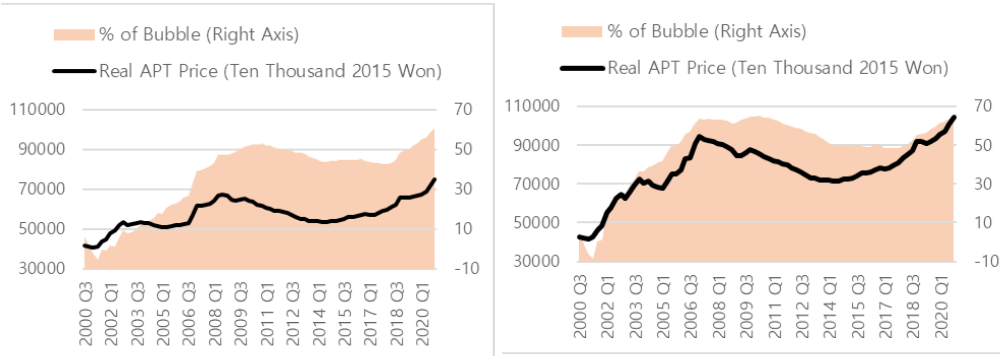


〈Figure 5〉 Probabilities of Explosive Bubble Regime in Gangnam Region

bubble component is quite different depending on the regime. In Gangbuk region for example, the AR coefficient of the bubble component is as explosive as 2.504 when the regime switches form the stable regime to the explosive one, whereas that in the non-explosive regime is stable at 0.899. Finally, two dichotomous bubble regimes are clearly identified in both regions. In the Gangnam region for example, the filtered probabilities for the explosive bubble regimes are presented in Figure 5. If we use the rule-of-thumb criterion of 50%, the bubble component in the Gangnam are exhibits explosive behavior in the early 2000:Q3-2001Q4, 2006:Q4-2012:Q3, and 2026:Q2 on.

To the extent that rent payments are free of non-fundamental bubbles, we can decompose the actual housing price into its fundamental and bubble parts as follows:

(3.18) $$p_t^f = pr_t^f + r_t, \quad p_t^b = p_t - p_t^f$$



(a) GB Submarket (b) GN Submarket

〈Figure 6〉 Real Housing Prices and the Share of Bubbles[20]

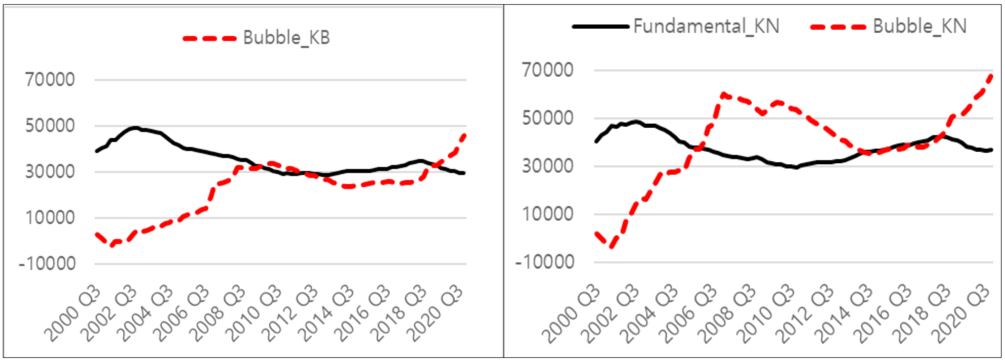
where p_t^f is the fundamental portion of the real house price, pr_t^f is the fundamental part of the price-rent ratio estimated by the present-value model, and p_t^b is the bubble portion of the real house price, all in logs.

Figure 5 plots the actual real housing prices and the percentage of estimated bubbles in each submarket. [19] According to the estimated present-value model, the two submarkets have been consistently ridden with speculative bubbles since the early 2000s, where the average percentage of bubbles is 36.3% and 48.3% in Gangbuk and Gangnam submarket, respectively. In both submarkets, the percentages of the bubble parts have moved in tandem with the actual prices, from which we deduce that speculative bubbles are the main source of the variations in housing prices in both submarkets.

More detailed results of housing price decomposition is shown in Figure 6, where the relative and absolute importance of the bubble component is quite different across the river. In Gangbuk area, the fundamental price has been stable hovering around the average of 35461.5, and the fundamental price has mostly been larger or comparable

(19) The real housing price series in Figure 5 are obtained as follows: we first rescale the nominal price indexes to match the median apartment prices in 2020 and divide the rescaled indexes with the CPI.

(20) Since the bubble is formed in the price-rent ratio (not in the price), the non-negativity constraint on the bubble term b_t is not imposed. As a result, small ‘negative’ bubbles are estimated for the early 2000s.



(a) GB Submarket (b) GN Submarket

〈Figure 7〉 Decp tomposition of Real Housing Prices

to the bubble price until the onset of the recent housing boom, despite the continued bubble buildup since the early 2000s. In Gangnam market, the estimated fundamental price is comparable to that in GB. For the bubble parts, however, two major episodes of bubble overshooting are detected in the southern part of Seoul during 2006:Q1-2014:Q1 and 2018:Q2 on. In the first episode, the average bubble price was 50304.5 overshooting the average fundamental price 32695.8 by 54%. The magnitude of overshooting in the second episode is 40.5% and smaller than in the first episode. Since the recent housing boom is viewed still ongoing in the latter part of 2021, however, the magnitude of overshooting is likely to be larger than the number shows for some time ahead.

The above results of the bubble-fundamental decomposition clearly demonstrate that the magnitude and dominance of housing bubble has been a lot more conspicuous in the Gangnam area, as can be seen from the timing, magnitude, duration of bubble overshooting, and the speed of bubble buildup. These findings strongly suggest that the housing price spillover between the two submarkets, if exits, originated mainly from the GN area, and that the fluctuations in bubble component are the main source of housing price spillover. We will examine these issues in more detailed and formal way in the next section.

4. Housing Price Spillover between Submarkets

In this section, we examine the presence of spillover or ripple effect between the two housing submarkets of Seoul in two steps. We first check if the housing prices in the two submarkets are tied down by a stable log-run relation, noting that the analysis of housing price spillover among different markets requires as a precondition the presence of a long-run relationship between prices in different regions.(21) We then undertake a pairwise Granger-type causality analysis, which is expected to identify which submarket plays a dominant role in the diffusion of housing price movement in Seoul. In so doing, we investigate the patterns of housing price diffusion separately for the bubble and fundamental parts.

4.1 Preliminary Evidence for Spillover Effects

As highlighted in Meen (1999), Petersen et al. (2002) and Cook (2003), failure to detect stationarity in the ratios suggests house prices in submarkets do not converge in the long-run, which in turn precludes the presence of spillover effects. We therefore test for the presence of long-run relations among housing prices in the two submarkets in two ways. We first employ Meen's (1999) constancy ratio test and check for the stationarity of a ratio of house price in one submarket to that in a broader market. The test provides a preliminary indicator of the existence of a spillover effect. We then proceed to run formal cointegration test to price series of the two submarkets.

To implement Meen's procedure, we run the ADF and PP test to the ratio of the purchase price of each submarket to those of the city of Seoul. Overall, the results in Table 3 reveal that the ratio in each case is stationary at the 1% to 10% significance levels and that there is long-run constancy in these ratios. These results give a preliminary indication that the housing market of Seoul is not entirely segmented

(21) Surprisingly enough, this key precondition is not checked in the literature of house price spillover, e.g., Vansteenkiste (2007), Costello et al. (2011), and Bago et al. (2021a, 2021b),

〈Table 3〉 Meens' Procedure to Test the Stationarity of Price Ratios

	Gangbuk to Seoul	Gangnam to Seoul
ADF	-3.150 (0.027)	-2.828 (0.058)
PP	-2.976 (0.01)	-2.632 (0.091)

Notes: The ADF and PP test the null of a unit root in the ratio of the housing price in a submarket to that of Seoul citywide.

〈Table 4〉 Johansen Cointegration Test

Null Hypo.	Between Actual Prices		Between Fundamentals		Between Bubbles	
	J_{trace}	$J_{max\ eig.}$	J_{trace}	$J_{max\ eig.}$	J_{trace}	$J_{max\ eig.}$
No. of CI=0	23.148 (0.003)	19.391 (0.007)	29.871 (0.001)	28.677 (0.001)	18.750 (0.016)	18.648 (0.010)
	J_{trace}	$J_{max\ eig.}$	J_{trace}	$J_{max\ eig.}$	J_{trace}	$J_{max\ eig.}$
No. of CI=1	3.756 (0.053)	3.756 (0.0536)	1.194 (0.275)	1.194 (0.275)	0.092 (0.762)	0.092 (0.762)

Note: p-values in parentheses.

over the long period of time and that a spillover effect is likely to exist in housing submarkets within Seoul.

Searching for a more formal piece of evidence for the spillover effect, we extend the scope of the analysis by checking the presence of a long-run cointegrating relationship between the actual, fundamental, and bubble components of housing prices across the two submarkets. This exercise is undertaken via Johansen's trace and maximum eigenvalue tests, where the lag length used in the VAR is based on Bayesian Information Criteria up to the maximum lags of 5.

The results of cointegration test indicate that there exists a long-run relation between the two submarkets. In terms of the p-values in parentheses, very strong evidence for the presence of cointegration is found, whether the test is run for the pair of fundamental housing prices or the bubble prices. We view this result as another support for the existence of an interlinkage between the regional markets in Seoul.

4.2 Spillover between the two submarkets

Although both the results of Meen's procedure and cointegration test are indicative of convergence or a spillover effect, they do not provide information about the patter of house price diffusion. We therefore proceed to examine how the diffusion of housing prices works in more detail. Our particular aim here is to see whether the housing prices are interconnected across the two submarkets, with an emphasis on finding the main source of inter-regional spillover or contagion. To do so, we utilize the results from section 2 of the test for and estimation of the speculative bubble in housing prices and apply the Granger causality test to analyze interlinkage between the actual, fundamental, and bubble components of the two submarkets.

In existing studies of the spillover effect, it is common to difference asset price data that are non-stationary so that a stable statistical model can be constructed. As frequently pointed out, e.g., Hendry (1995), Reiss (2015), and Bianco (2018), however, the practice of differencing data inherently involves loss of information. For data series contain common stochastic trends in their levels, this problem can be even more serious, as posited in Fulkey and Bonham (2015). Differencing such data breaks the cointegrating link among the series, and some of the signal leaks out to the idiosyncratic components which do not contribute to the transfer of information among indicators. This in turn renders the statistical model mis-specified and may lead to poor forecasts and inaccurate test results.

In running the causality test, therefore, we note the need for considering the presence of the long-run relations between the housing prices of the two submarkets as an 'anchor' around which the short-run spillover or contagion may takes place. That being the case, the appropriate form of the test equation is of the error-correction form

$$\Delta P_t^i = c + \gamma(CE_{t-1}^i) + A_1\Delta P_{t-1}^i + A_2\Delta P_{t-3}^i + \cdots A_p\Delta P_{t-p}^i + \varepsilon_t, \tag{4.1}$$

where P_t is the 2 by 1 vector of housing prices (in logs if possible) in the two

〈Table 5〉 Results of Granger Causality Test

Null Hypothesis	Actual Price		Fundamental Part		Bubble Part	
	F-stat	χ^2-stat	F-stat	χ^2-stat	F-stat	χ^2-stat
GN $\nrightarrow$ GB	3.745* (0.005)	18.726* (0.002)	0.264 (0.931)	1.321 (0.933)	3.897* (0.004)	19.487* (0.002)
GB $\nrightarrow$ GN	1.484 (0.208)	7.419 (0.193)	1.231 (0.305)	6.155 (0.291)	1.971 (0.095)	9.855 (0.080)

Note: p-values in parenthesis, and * denotes rejection of the null hypothesis at 1% significance level.

supermarkets, CE_t is the cointegration error and p is the number of lags. As in Table 4, we estimate the above error correction model for three pairs of housing price in the two submarkets, so the superscript i =1, 2, 3 denoted the pairs of the whole, fundamental, and bubble part of housing prices, respectively. When running the causality test, we treat the cointegrating vectors estimated by OLS as exogenous regressors. Also, the estimation of (14) for the pair of bubble components are done with their levels due to the occurrences of negative bubbles in the early 2000s.

Once the test equation (14) is estimated, we check the presence and direction of causality by running the Wald test as to whether the lagged differences of the housing price in one region help better predict those in the other region. The results of the causality test are shown in Table 7, where a few conspicuous findings emerge.

For the actual housing price series of the two submarkets, the test results reveal a unidirectional spillover from Gangnam to Gangbuk submarket. In the firs column, both the F- and χ^2- statistics indicate that the changes in actual housing prices in the Gangnam do affect the future prices in the Gangbuk, rejecting the null of no causality in that direction at any practical level of significance. In contrast, the test statistics for the causality from Gangbuk to Gangnam are too small to reject the null of no short-run spillover even at the 10% significance level. This unidirectional causality in turn implies that the Gangnam submarket is likely to be the dominant submarket in Seoul and that the Gangnam submarket contains useful information that can be used to explain the future movement of house prices in the other one.

Nevertheless, there is no evidence for spillover in either direction between the fundamental prices of the two regions. As shown in the second column, both tests fail to reject the null of no causal relation between the two regions. To the extent that the test being performed is about the significance of the short-run spillover, however, a caution is required in interpreting these results. Since the long-run relationship between the fundamental house prices of the two submarkets is and should be present in the test equation, the correct interpretation is: once the fundamental housing prices of the two submarkets have been fully aligned in accordance with their long-run relationship, there is no evidence for any further discernible short-run spillover among fundamental housing prices.[22]

The two sets of results above lead to the conjecture that the short-run spillover of house prices occurs via the contagion of housing bubbles, and this conjecture is confirmed in the last column. As shown in the last column, both tests support the causal relation only running from Gangnam to Gangbuk and the magnitudes of the test statistics and their p-values are very close to those for the pair of actual house prices shown in the first column. These results therefore support that, in addition to the circulatory rally around the fundamental house prices between the two submarkets, there is a considerable degree of short-run bubble contagion from Gangnam to Gangbuk.

5. Conclusion

As an addition to the expanding literature on the transmission of housing prices among adjacent submarkets, this study investigates the interlinkages between the regional housing markets in Seoul, Korea by examining how speculation in one region within the city transmits to the other region. The study focuses on the two decades since 2000, a period that covers the significant recent boom and bust in the

(22) In the housing market of Seoul, upward adjustments in the housing prices in Gangbuk following increases in Gangnam housing prices are frequently observed and explained as the results of ‘circulatory rallies’ within the city.

real estate market of Korea. Before conducting the analysis on possible spillovers of speculative bubbles between regions, we first apply the GSADF test of Phillips et al. to test for the presence of speculative bubbles that gestate and collapse intermittently in each of the two main submarkets of Seoul, i.e., Gangbuk and Gangnam. Based on the results of GSADF test that support the presence of periodically collapsing bubble in both submarkets, we then construct a version of present-value model by which to separately identify the fundamental and bubble components of house prices in each submarket. Finally, we investigate the possibility of spillovers in the fundamental and bubble components across the regional housing markets in two steps. As a precondition for the following analysis of inter-regional spillover in the short-run, we first check the presence of stable long-run relationships between the fundamental and bubble components of house prices across the submarkets. We then implement a Granger-type causality test using a bivariate VEC model comprising the pair of actual, fundamental, and bubble prices of the two submarkets, to see whether short-run ripple effects or bubble contagion effects are present, on top of the corrections imposed by the long-run relationships between the two markets.

Some key findings emerge from the current study. First, the GSADF test supports that housing bubbles existed in the two housing submarkets, especially in the two periods during the mid- to late 2000s and from 2017 on. The results of fundamental-bubble decomposition also reveal that there have been accumulations of bubble on either side of the river since the mid-2000s. Second, stable long run relationships are found between the southern and northern parts of Seoul, for the pair of the actual, fundamental, and bubble prices alike. This indicates that the two submarkets are not segmented but converge to a single market over time and that there is a ripple effect within a greater single housing market. Third, the causality test shows that there is a diffusion of house price between the two submarkets. More specifically, the diffusion identified by the test works in the direction from Gangnam to Gangbuk confirming the dominant role of the high-priced submarket in the diffusion of price increases. Furthermore, such diffusion of prices appears not between the fundamental components but between the bubble components, strongly support the case of short-run bubble contagion from Gangnam to Gangbuk.

In summary, this investigation confirms the presence of housing price spillover and bubble contagion in Seoul, from the southern part of the city (where properties are relatively high-priced) to the northern part (where average prices about 30% lower). The results of the current study also allow us to identify the ‘price leader’ between submarkets. Authorities then must address the gestation of overvaluation or possibly bubbles in house prices at its origination to prevent this bubble from transmitted to the north of the river to reduce speculation in the housing market in the first place.

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Appendix A: State-Space Form of the Present-Value Model

Applying the law of iterated expectation to the fundamental part of the price-rent ratio in (7), we have

(A.1) $$pr_t^f = \frac{\kappa}{1-\rho} + \frac{\gamma_0 - \delta_0 - \theta_0}{1-\rho} + B_1 \begin{bmatrix} g_t \\ g_{t-1} \end{bmatrix} - B_2 \begin{bmatrix} \mu_t \\ \mu_{t-1} \end{bmatrix} - B_3 \begin{bmatrix} \lambda_t \\ \lambda_{t-1} \end{bmatrix},$$

where $B_1 = \rho[1\ \ 0]\left(I - \rho \begin{bmatrix} \gamma_1 & \gamma_2 \\ 1 & 0 \end{bmatrix} \right)^{-1}$, $B_2 = \rho[1\ \ 0]\left(I - \rho \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} \right)^{-1}$,

and $B_3 = \rho[1\ \ 0]\left(I - \rho \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} \right)^{-1}$.

The transition equations of the model are cast into the following form:

(A.2) $$X_t = \begin{bmatrix} 0_{2\times1} \\ 0_{2\times1} \\ 0_{2\times1} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ \bar{b}(S_t) \end{bmatrix} + \begin{bmatrix} \begin{bmatrix} \gamma_1 & \gamma_2 \\ 1 & 0 \end{bmatrix} & 0_{2\times2} & 0_{2\times2} & 0_{2\times7} \\ 0_{2\times2} & \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} & 0_{2\times2} & 0_{2\times7} \\ 0_{2\times2} & 0_{2\times2} & \begin{bmatrix} \delta_1 & \delta_2 \\ 1 & 0 \end{bmatrix} & 0_{2\times7} \\ \multicolumn{4}{c}{0_{1\times13}} \\ \multicolumn{4}{c}{0_{1\times13}} \\ \multicolumn{4}{c}{0_{1\times13}} \\ \multicolumn{4}{c}{0_{1\times13}} \\ \multicolumn{4}{c}{0_{1\times13}} \\ \multicolumn{4}{c}{0_{1\times12}\ \ F_b(S_t)} \end{bmatrix} X_{t-1} + \begin{bmatrix} & C_G & \\ & C_M & \\ & C_\wedge & \\ I_6 & & 0_{6\times1} \\ 0_{1\times6} & & 1 \end{bmatrix} \begin{bmatrix} u_t^r \\ u_t^i \\ u_t^\pi \\ \varepsilon_t^\mu \\ \varepsilon_t^\lambda \\ \varepsilon_t^b \end{bmatrix}$$

$$(X_t = A(S_{t-1}) + F(S_{t-1})X_{t-1} + C\eta_t),$$

where $X_t = \left[g_t, g_{t-1}, \mu_t, \mu_{t-1}, \lambda_t, \lambda_{t-1}, u_t^r, u_t^i, u_t^\pi, \varepsilon_t^g, \varepsilon_t^\mu, \varepsilon_t^\lambda, b_t \right]'$, and

$$C_G = \begin{bmatrix} 0001000 \\ 0_{1\times7} \end{bmatrix}, C_M = \begin{bmatrix} 0000100 \\ 0_{1\times7} \end{bmatrix}, C_\Lambda = \begin{bmatrix} 0000010 \\ 0_{1\times7} \end{bmatrix},$$

$$\bar{b}(S_t) = \bar{b}(1-S_t) - \frac{q}{1-q}\bar{b}S_t(1-S_{t-1}) - \frac{p}{1-p}\bar{b}S_tS_{t-1}, \text{ and}$$

$$F_b(S_t) = \psi(1-S_t) + \frac{1}{1-q}\left(\frac{1}{\rho} - q\psi \right) S_t(1-S_{t-1}) + \frac{1}{p}\left(\frac{1}{\rho} - (1-p)\psi \right) S_tS_{t-1}.$$

When $pr_t = pr_t^f + b_t$ is inputted, we write the observation equations as

$$(A.3)\quad \begin{bmatrix} \Delta r \\ i_t \\ \pi_t \\ pr_t \end{bmatrix} = \begin{bmatrix} \gamma_0 \\ \delta_0 \\ \theta_0 \\ \frac{\kappa}{1-\rho} + \frac{\gamma_0 - \delta_0 - \theta_0}{1-\rho} \end{bmatrix} + \begin{bmatrix} 01 & 00 & 00 & 10 & 00 & 0 & 0 & 0 \\ 00 & 01 & 00 & 01 & 00 & 0 & 0 & 0 \\ 00 & 00 & 01 & 00 & 10 & 0 & 0 & 0 \\ B_1 & B_2 & B_3 & 00 & 00 & 0 & 0 & 1 \end{bmatrix} X_t$$

Taking the possible explosiveness of the bubble into account, we seed the Kalman filter with an arbitrarily large variance for the initial bubble term, assuming that the initial value of the bubble is $\overline{b}$. Fixing the initial value of the bubble at 0 does not yield any significant changes in the estimation results.

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